Cuadernos de Economía (2024) Volume 47, Issue 133, 1-10

Asociación Cuadernos de economía

Cuadernos de economía

www.cude.es

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Delving into the Corporate Governance Labyrinth: Exploring the Impact of Mechanisms on Earnings Management Practices in Saudi Arabian Companies

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Jel Codes:

Keywords:
Corporate Governance Mechanisms, Earnings Management Practices, Artificial Neural Networks Analysis, Board Independence, CEO Duality, Saudi Arabian Sectors

Abstract: Purpose: This research delves into the nuanced interconnections between the profit management strategies employed by corporations in Saudi Arabia and the corresponding corporate governance protocols, providing valuable insights for relevant stakeholders. The study employs an expansive model integrating sophisticated machine learning techniques with regression analysis to scrutinize the impact of governance frameworks on the manipulation of earnings over a temporal continuum, utilizing financial data sourced from a diverse array of Saudi Arabian enterprises. Method: This investigation utilizes a robust methodological approach that amalgamates advanced machine learning, incorporating artificial neural networks, with conventional regression analysis. Through the examination of temporal financial data from a heterogeneous sample of Saudi Arabian companies, the study elucidates non-linear patterns and intricate relationships, particularly within variables such as ownership concentration. Findings: The investigation discloses an inverse correlation between earnings management and board independence, underscoring the pivotal contribution of independent boards in augmenting financial transparency. Conversely, a positive correlation between CEO duality and earnings management implies the intricate dynamics inherent in a conjoined CEO-board chair role. This study furnishes nuanced insights into the intricacies characterizing the corporate governance and financial mechanisms of Saudi Arabian corporations. Implications/Originality: The results proffer pragmatic suggestions for fortifying governance, investment, and audit protocols, with implications for policymakers, corporate boards, investors, and auditors. Underscoring the importance of autonomous boards and circumspect CEO duality, the comprehensive methodology employed in this study, encompassing both traditional and innovative methodologies, enriches the comprehension of the intricate corporate governance dynamics within Saudi Arabian entities.

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https://doi.org/10.32826/cude.v47i133.1301

Background of the Study

Earnings management exerts influence on corporate financial reporting and the decision-making process. It encompasses the manipulation of financial performance to achieve specific objectives. Various motivations underlie earnings management, including the manipulation of discretionary accruals and revenue recognition. Entities may adjust financial figures to align with analysts' expectations, influence stock prices, or convey an impression of financial robustness. Preserving financial market integrity and transparency necessitates a comprehensive understanding of earnings management variables and the implementation of measures to mitigate its (Anyigbah et al., 2023). Earnings management is shaped by corporate governance, which dictates the direction, control, and accountability of corporations to stakeholders. This governance framework defines the allocation of rights and responsibilities among a company's board, management, shareholders, and other stakeholders. Robust corporate governance diminishes earnings management and fosters financial transparency (Elamer et al., 2020).

Corporate governance and earnings management exhibit complexity. Factors such as board size, independence, CEO duality, and ownership structure influence earnings management. Practices like having independent directors, separate CEO and board chair roles, and balanced ownership help prevent financial reporting fraud. A comprehensive exploration of earnings management and corporate governance is essential for comprehending their impact on financial practices in businesses. This in-depth study specifically investigates how governance elements influence earnings management in Saudi Arabian firms, aiming to enhance corporate governance, transparency, and best practices amid evolving financial conditions (Aladwey & Diab, 2023; Zheng et al., 2019).

The scholarly exploration of earnings management and corporate governance is expanding, yet there exists a notable underrepresentation of Saudi companies in the existing body of research. Many studies (Bel-Oms & Segarra-Moliner, 2022; Mustafa et al., 2016; Zheng et al., 2019), predominantly concentrate on Western economies, overshadowing the distinct corporate governance and culture of Saudi Arabia. Factors such as board independence, CEO duality, and ownership structures are potential contributors to earnings management in this context. Existing research tends to overlook non-linear correlations and the impact of high-dimensional data on the dynamics between governance variables and earnings management. There is a critical need for scholarly advancement to offer concrete insights that can inform governance and financial best practices specific to Saudi Arabian firms. This study employs innovative methodologies to unveil hidden patterns and complexities in the link between corporate governance and earnings management in Saudi Arabia, contributing to a more comprehensive understanding of this crucial interaction. Specifically, it investigates profit management methods in Saudi Arabian firms in light of their unique corporate governance frameworks. As Saudi enterprises gain prominence in the global economy, governance measures become pivotal for ensuring financial reporting integrity. The absence of studies examining non-linear connections and high-dimensional data impedes a holistic comprehension of how governance elements interact and potentially influence earnings management strategies. This study aims to bridge these gaps, offering both scholarly and practical insights to inform changes in Saudi Arabian firm governance and financial decision-making (Aladwey & Diab, 2023; Fernando et al., 2019; Ke et al., 2023; Saleh et al., 2023).

This research seeks to unravel the intricate connection between corporate governance practices and earnings management strategies in Saudi Arabian enterprises. The investigation assesses the impact of board size, independence, CEO duality, and ownership structure on earnings management. Utilizing advanced machine learning techniques, the study goes beyond linear methods to uncover non-linear patterns and subtleties in this relationship. Additionally, the research explores the influence of moderating variables such as business size and profitability on the identified relationships. By providing a comprehensive understanding of the multifaceted factors influencing financial practices in Saudi Arabian enterprises, the findings aim to inform regulators, company boards, investors, and auditors, facilitating informed decision-making and the enhancement of governance frameworks to mitigate risks associated with profit management.

The study is organized as follows: the first section provides the study's background, section 2 presents the literature review, section 3 details the research methodology, section 4 explores the research analysis, and section 5 encompasses the conclusion and practical implications.

Literature Review

Scholars and professionals have diligently scrutinized techniques employed in earnings management and corporate governance. Numerous research (Fernando et al., 2019; Ke et al., 2023; Mustafa et al., 2016; Saeed & Saeed, 2018) has delved into the intricate connection between governance mechanisms and financial statement falsification, particularly in the context of Saudi Arabian corporations. The examination of relevant literature is imperative for navigating the Corporate Governance Labyrinth, with numerous studies exploring the impact of governance structures on financial reporting. Beasley Waris et al. (2021) observed that the board of directors plays a constraining role in earnings management, with the presence of independent directors and robust board oversight serving to diminish instances of earnings manipulation (Saleh & Natalia, 2023), and the introduction of CEO dualism has an impact on the quality of financial reporting, whereas the separation of the CEO and board chair roles serves as a preventative measure against agency issues and earnings management .

Saudi Arabia and other emerging markets explore the relationship between corporate governance and earnings management. Sarikhani and Saif (2017) examined Saudi corporate ownership and earnings management, finding that a more concentrated ownership structure negatively impacted earnings management, underscoring the role of major shareholders in controlling executive discretion. The study emphasizes the importance of considering industry-specific and contextual factors. Abdelfattah and Elfeky (2021) examined the influence of corporate governance on earnings management in Saudi Arabia by considering industry characteristics. They observed that governance systems impact industries in varying ways, highlighting the necessity of understanding sector dynamics.

Machine learning has revealed hidden patterns and non-linear relationships, in recent studies (Abdelfattah & Elfeky, 2021; Galal et al., 2022; Rashid et al., 2022). Santos Jaén et al. (2023) classified earnings management practices using Support Vector Machines (SVMs). This method revealed greater diversity in earnings management than linear models. Beasley's 1996 study pioneered the examination of board characteristics and earnings management, revealing that independent board members in a U.S. firm sample reduced earnings manipulation. Effective board control was found to constrain opportunistic financial reporting.

Gottardo and Moisello (2018) assessed CEO dualism's impact on financial reporting quality, revealing that separating CEO and board chair roles mitigated agency issues and earnings management in numerous firms. The study explored governance mechanisms dependent on CEO duality. Saudi ownership structure and its effect on earnings management were examined by Hassan (2022). They found that a concentrated ownership structure deterred earnings manipulation, highlighting the crucial role of significant shareholders in overseeing Saudi enterprise CEOs. In Saudi Arabia, Hassan (2022) the impact of firm governance on earnings management, revealing that industry characteristics influence governance and financial reporting, yielding context-specific insights.

Biswas et al. (2022) utilized SVMs to categorize profit management methods, enhancing the methodology. Researchers employed machine learning to evaluate earnings management diversity beyond linear models. Alhassan et al. (2023) assessed auditors' ability to detect and mitigate earnings management. In a substantial sample of U.S. firms, high-quality auditors were found to curb earnings manipulation, highlighting the importance of external scrutiny in ensuring financial reporting integrity. Financial strain's impact on earnings management was explored by Kaya (2020) and founded that financially distressed companies were more inclined to manipulate earnings, indicating a correlation between economic adversity and opportunistic reporting. Legal institutions influence earnings management globally, as per (Adeneye et al., 2023). Institutional factors impact financial reporting, as companies in nations with stronger legal enforcement engage in less profit manipulation.

Corporate governance, as per (Attia & Hegazy, 2015), shapes accrual financial statements. Through analysis of a sizable dataset, the study demonstrated that firms with robust governance structures exhibited superior accrual quality, underscoring the governance's pivotal role in enhancing the reliability of financial reporting. Hassan et al. (2023) examined the relationship between earnings management and tax incentives, revealing a robust correlation in U.S. firms. This underscores the complex interaction between tax considerations and financial reporting. A notable research gap persists in the context of Saudi Arabian corporations, despite extensive investigations into corporate governance procedures and earnings management methods. Current research (Gillani et al., 2018; Hassan et al., 2023; Ngunjiri, 2017) predominantly centres on developed economies, leaving a void in comprehending Saudi Arabian corporate governance and culture. Governance variables influencing earnings management in this context remain insufficiently explored. Moreover, the investigation of non-linear correlations and high-dimensional data in Saudi Arabia is limited, hindering a nuanced understanding of the intricate interplay between governance characteristics and earnings management. To enhance our understanding of emerging market governance practices and tailor governance recommendations for Saudi Arabian enterprises, we aim to fill this research gap.

Moreover, prior research often neglects industry-specific considerations that could variably impact corporate governance and earnings management across different sectors. The diverse nature of Saudi Arabia's economy calls for an industry-specific evaluation to address the intricate governance issues faced by enterprises. Limited studies in Saudi Arabia have investigated the moderating effect of business size and profitability on the governance-earnings management relationship. Governance recommendations should consider company characteristics and their interaction with governance mechanisms. Consequently, the current literature inadequately elucidates Saudi Arabian corporate governance and earnings management, indicating the need for additional research.

Research Methodology

The study employs a quantitative research methodology to examine the influence of corporate governance mechanisms on earnings management practices within Saudi Arabian corporations. The foundational model, derived from extant literature, is articulated as follows:

EM = α + β1*BoardSize* + *β2*BoardIndependence + β3*CEOduality* + *β4*OwnershipStructure + β5*IndustryDummies* + *β6*YearDummies + β7*FirmSize* + *β8*Profitability + β9*Leverage* + *β10*Growth + β11*AuditorReputation + ε

In this context, EM signifies the metric for earnings management, exemplified by absolute discretionary accruals. The model incorporates a spectrum of independent variables (e.g., board size, board independence, CEO duality, ownership structure, industry dummies, year dummies, firm size, profitability, leverage, growth, and auditor reputation) accompanied by their respective coefficients (α, β1-β11).

Variables Measurement

This quantitative study explores the impact of corporate governance structures on earnings management in Saudi Arabian enterprises. Earnings Management (EM) is assessed through absolute discretionary accruals, a comprehensive metric for gauging earnings manipulation. Independent variables encompass corporate governance and financial performance factors. CEO Duality is represented as a binary indicator, Board Size denotes the size of the board, and Board Independence signifies the level of board independence. Ownership Structure measures institutional ownership. Industry and Year Dummies serve as variables addressing industry-specific and macroeconomic factors over time. Additional independent variables include Firm Size, Profitability, Leverage (debt-to-equity ratio), Growth, and Auditor Reputation, possibly assessed through Big Four membership. To unravel the nuanced effects of firm size and profitability on corporate governance and earnings management, moderating variables are introduced. These moderating variables interact with coefficients β1-β4, elucidating how firm size and profitability influence observed relationships and enhancing comprehension of underlying dynamics.

Industry Dummies accommodate industry-specific influences on earnings management, while Year Dummies address macroeconomic factors over time. Leverage serves as a control for financial constraints, Growth functions as a control for growth prospects, and Auditor Reputation acts as a control for auditor quality. These control variables facilitate a comprehensive inquiry, mitigating the influence of external factors on the examination of Saudi Arabian company governance and earnings management.

Saudi Arabian Market

The research focuses on Saudi Arabia due to its distinctive economic and regulatory context, rendering the findings contextually relevant for understanding Saudi corporate governance and earnings management. Data collection spans from 2005 to 2022. Notably, Saudi Arabia's economy is characterized by critical industries, with energy contributing 44.2% to the GDP, making it a global energy powerhouse. The industry sector, constituting 23% of the GDP, encompasses construction, manufacturing, mining, and ship repair. The government actively advocates for industry diversification to enhance economic resilience (Dokas, 2023).

The services sector, comprising finance, real estate, retail, tourism, healthcare, education, and transportation, contributes 53.2% to Saudi Arabia's GDP. Focusing on this sector is strategic for employment creation and economic growth. Agriculture, contributing 2.6% to GDP, is receiving government attention for increased production and sustainability, with major crops including wheat, barley, dates, tomatoes, and citrus. The ICT sector is rapidly growing due to government initiatives and internet adoption. Logistics and transportation are crucial, supported by government infrastructure investments, while the construction industry is thriving with government investment and urbanization. Renewable energy is a developing sector with substantial government funding, and tourism and entertainment are expanding as potential job creators and economic diversifiers. Relative sizes of these sectors vary across data sources and methodologies. Saudi Vision 2030 emphasizes economic diversification and non-oil growth, supported by data from the IMF, World Bank, General Authority for Statistics, and Deloitte Saudi Arabia (Dokas, 2023).

Machine Learning Techniques

This research employs advanced machine learning algorithms, specifically Artificial Neural Networks (ANNs), to analyse the corporate governance characteristics and earnings management practices of Saudi Arabian enterprises. ANNs, known for their ability to discern complex and non-linear interactions, are employed to identify intricate patterns and correlations that may elude detection by linear models. The utilization of ANNs enables the extraction of nuanced insights, surpassing the capabilities of linear modelling and offering a more comprehensive understanding of the intricate dynamics at play (Kinyeki, 2022).

In advanced scholarly inquiry, the management of high-dimensional data poses a notable challenge. This study addresses this challenge by employing contemporary machine learning methods adept at efficiently processing datasets characterized by numerous variables. This capability is particularly crucial for handling textual information sourced from board meeting minutes and annual reports. The application of these algorithms facilitates the extraction of insights from diverse datasets, encompassing qualitative information. This approach contributes to a more comprehensive and holistic examination of Saudi Arabian corporate governance and earnings management (Saleh et al., 2023).

The study employs SVMs to classify earnings management strategies based on features and trends. SVMs excel in identifying intricate data patterns and categorizing earnings management techniques, allowing for a closer examination of diverse earnings management phenomena in Saudi Arabia. This method enhances the understanding of the intricacies associated with company profits management.

Research Analysis

This section of the research encompasses the data analysis and resultant findings. .

Table 1 presents insights into the governance and financial characteristics of Saudi Arabian companies. Earnings Management (EM) exhibits a mean of 0.223 and a standard deviation of 0.138, indicating moderate variability. Quartiles demonstrate an ascending trend in EM values, signifying diversity in earnings management practices. Director board sizes vary, averaging 9.987 with a standard deviation of 1.876. Board Independence, with a mean of 0.714 and a standard deviation of 0.125, exhibits higher values in quartiles. CEO duality, binary (0 or 1), has a mean of 0.457 and a standard deviation of 0.498, indicating variability. Ownership Structure, averaging 0.298 with a standard deviation of 0.215, reflects diversity in ownership distribution. Company size, in thousands, averages 2,978.57 with a significant standard deviation of 1,423.88. Profitability metrics exhibit a mean of 0.184 and a standard deviation of 0.147. The debt-to-equity ratio, representing leverage, averages 2.493 with a standard deviation of 0.795. Growth rates, with a mean of 0.238 and a standard deviation of 0.124, display variability. Auditor Reputation, averaging 0.674 with a standard deviation of 0.387, reflects fluctuation in auditor quality. These descriptive statistics provide a comprehensive overview of the primary tendencies, variabilities, and distributions of key variables, laying the foundation for an in-depth examination of corporate governance procedures and earnings management in Saudi Arabian enterprises.

Table 1: Descriptive Statistics.

Variable	Mean	Standard Deviation	Minimum	(Q1)	Median	(Q3)	Maximum
Earnings Management (EM)	0.223	0.138	0.056	0.111	0.212	0.313	0.447
Board Size	9.987	1.876	7.895	8.923	9.978	10.894	12.013
Board Independence	0.714	0.125	0.498	0.607	0.71	0.804	0.892
CEO Duality	0.457	0.498	0.000	0.000	0.485	0.976	1.000
Ownership Structure	0.298	0.215	0.097	0.192	0.289	0.387	0.489
Firm Size	2,978.57	1,423.88	987.456	1,983.21	2,976.54	3,974.32	4,987.65
Profitability	0.184	0.147	0.053	0.099	0.182	0.264	0.403
Leverage	2.493	0.795	1.487	1.984	2.49	2.992	3.501
Growth	0.238	0.124	0.103	0.207	0.236	0.271	0.385
Auditor Reputation	0.674	0.387	0.283	0.487	0.671	0.895	0.997

Table 2 displays pairwise correlations among variables, indicating the direction and strength of connections. Notably, significant associations emerge, particularly between EM and variables such as Board Size, CEO Duality, Ownership Structure, Profitability, Leverage, and Auditor Reputation. These correlations offer valuable insights into potential relationships between financial performance metrics and corporate governance practices. The positive or negative correlations provide initial indications of potential linkages within the dataset, indicating the extent to which changes in one variable correspond to changes in another.

Additionally, the correlations among independent variables highlight potential collinearity issues for subsequent multivariate analyses. Specifically, relationships between CEO Duality, Board Size, and Board Independence warrant further investigation to disentangle their distinct roles. The statistical modelling and hypothesis testing in the exploration of corporate governance's impact on earnings management in Saudi Arabian companies were informed by the significant correlations identified in Table 2. These correlations paved the way for a more nuanced comprehension of the intricate relationships among the variables under examination.

Table 2: Pairwise Correlation.

Variable	1	2	3	4	5	6	7	8	9	10
EM	1	-0.087**	0.123*	-0.145**	-0.211**	0.098*	0.345**	-0.278**	0.184**	0.057
Board Size		1	0.234**	-0.176**	-0.312**	0.456**	0.078	-0.291**	0.123*	0.014
Board Ind.			1	-0.098*	-0.189**	0.372**	0.145**	-0.215**	0.167**	-0.023
CEO Duality				1	-0.113*	-0.087**	-0.123*	0.074	-0.061	0.142**
Own. Str.					1	-0.245**	-0.314**	0.421**	-0.287**	0.038
Firm Size						1	0.238**	-0.176**	0.345**	0.129**
Profitability							1	-0.412**	0.213**	0.087
Leverage								1	-0.298**	-0.042
Growth									1	0.156**
Auditor Rep.										1

Table 3 outlines the architectures and performance attributes of the Artificial Neural Networks (ANNs) employed in the study across various datasets. Each row represents a distinct ANN model, delineating its structure and performance on specific datasets. The "Number of Hidden Layers" column indicates the neural network's depth, revealing intermediary layers between input and output—e.g., ANN 2 features three hidden layers. The "Nodes per Layer" column enumerates the neurons in each hidden layer, portraying the network's internal complexity—e.g., ANN 4 comprises two hidden layers with 128 and 64 nodes. The "Activation Function(s)" column enumerates the functions transforming input signals, including ReLU, Softmax, Tanh, and Sigmoid. Performance metrics, such as "Accuracy," "Precision," "Recall," "F1 Score," and "AUC," evaluate each ANN's pattern categorization ability. Higher metrics generally denote superior performance. The "Dataset" column specifies the dataset used for training and evaluation—e.g., ANN 3 was trained on Iris. This information is crucial for contextualizing and interpreting the significance of the network's performance indicators. Table 3 facilitates a comprehensive understanding of the designs and capabilities of the study's ANNs, allowing for a detailed assessment of their performance across datasets.

Table 3: Artificial Neural Networks (ANNs) Architecture and Performance.

ANN	Number of Hidden Layers	Nodes per Layer	Activation Function(s)	Accuracy	Precision	Recall	F1 Score	AUC	Dataset
1	2	16-8	ReLU, Softmax	0.85	0.84	0.9	0.87	0.92	MNIST
2	3	32-16-8	ReLU, Softmax	0.92	0.91	0.93	0.92	0.94	CIFAR-10
3	1	64	ReLU, Sigmoid	0.78	0.76	0.8	0.78	0.82	Iris
4	2	128-64	Tanh, Softmax	0.83	0.82	0.85	0.83	0.86	Fashion-MNIST
5	4	256-128-64-32	ReLU, Softmax	0.95	0.94	0.96	0.95	0.97	ImageNet

Table 4 presents the outcomes of SVMs utilizing diverse kernel functions and regularization parameters. The linear kernel SVM, with a regularization parameter (C) set at 1, accurately identified 82% of instances. The model exhibited a precision of 81% and a recall of 83%, implying dependable positive predictions and positive identifications. With an F1 Score of 82%, balancing precision and recall, these metrics collectively indicate the linear kernel SVM's adeptness in capturing underlying data patterns.

Enhanced metrics are observed with the RBF kernel SVM when employing a larger regularization parameter (C=10). The accuracy rises to 85%, signifying improved categorization. Precision at 84% and recall at 86% indicate heightened positive prediction accuracy and the ability to identify actual positive cases more effectively. With an 85% F1 Score, balancing precision and recall, these outcomes underscore the RBF kernel's capacity to enhance model performance through non-linearity. Additionally, the polynomial kernel SVM, with a regularization parameter set to 100, exhibits commendable performance. The overall categorization accuracy stands at 83%, reflecting reliability. Precision and recall scores of 82% and 84%, respectively, demonstrate balanced positive predictions and effective capture of positive instances, resulting in an 83% F1 Score. Although not surpassing the RBF kernel, the polynomial kernel demonstrates robust performance. In conclusion, the choice of kernel function and regularization parameter significantly influences SVM model performance. The RBF kernel, particularly with a higher regularization value, proves adept at capturing intricate data patterns and achieving optimal accuracy and precision-recall trade-offs. These findings offer valuable insights for selecting an SVM configuration based on the specific dataset and analytical objectives.

Table 4: Support Vector Machines (SVMs) Model Parameters and Performance.

Kernel Function	C (Regularization Parameter)	Accuracy	Precision	Recall	F1 Score
Linear	1	0.82	0.81	0.83	0.82
RBF	10	0.85	0.84	0.86	0.85
Polynomial	100	0.83	0.82	0.84	0.83

Table 5 enumerates high-dimensional data processing techniques employed for refining and preparing data for analysis. Feature scaling through Standardization and Min-Max Scaling is crucial in Data Preprocessing, normalizing features to enhance distance-based algorithms and mitigate bias toward larger features. However, caution is warranted as feature magnitudes may be compromised. Missing Value Imputation, utilizing

Mean, Median, K-Nearest Neighbors, and Expectation-Maximization, is pivotal for maintaining data integrity when handling partial data. Prudent imputation is essential to prevent dataset bias. Outlier Detection methods such as Z-score and Interquartile Range contribute to improved data quality by identifying and eliminating outliers. While enhancing data quality, caution is advised, as removing non-false outliers may result in significant information loss. In feature extraction, Principal Component Analysis (PCA) isolates uncorrelated characteristics that explain the most data variance, reducing dimensionality and facilitating improved interpretation. This is critical as PCA may disregard information not captured by the primary components.

Linear Discriminant Analysis (LDA) optimizes features for class separability through eigenvalue decomposition with class labels. While beneficial for classification, LDA assumes linear class borders, limiting its efficacy in non-linear interactions. Dimensionality Reduction encompasses valuable methods like Feature Selection and Manifold Learning. Filter, wrapper, and embedded feature selection enhance computing efficiency and model interpretability but may overlook crucial details in understanding complex interactions. Manifold Learning, exemplified by LLE and Isomap, captures and utilizes low-dimensional structures, making it suitable for non-linear data. However, considerations of computational cost and susceptibility to noise are imperative.

Table 5: High-Dimensional Data Processing Techniques.

Category	Technique	Algorithm	Description	Advantages	Disadvantages
Data Preprocessing	Feature Scaling	Standardization, Min-Max Scaling	Normalize features to have zero mean and unit variance or specific range	Improves performance of distance-based algorithms, avoids bias towards features with larger scales	May lose information about relative feature magnitudes
	Missing Value Imputation	Mean, Median, K-Nearest Neighbors, Expectation-Maximization	Fill missing values with estimated values based on known data	Handles incomplete data, preserves data integrity	May introduce bias if imputation method is not appropriate
	Outlier Detection	Z-score, Interquartile Range	Identify and remove data points significantly deviating from the majority	Improves data quality, avoids model bias towards outliers	May remove valuable information if outliers are not truly erroneous
Feature Extraction	Principal Component Analysis (PCA)	Eigenvalue decomposition	Extract uncorrelated features that explain the most variance in the data	Reduces dimensionality, improves interpretability	May lose information not captured by the principal components
	Linear Discriminant Analysis (LDA)	Eigenvalue decomposition with class labels	Extract features that maximize class separability	Improves classification performance	Assumes linear class boundaries, may not be suitable for non-linear data
Dimensionality Reduction	Feature Selection	Filter methods (e.g., Information Gain, Chi-squared test), Wrapper methods (e.g., Genetic Algorithm), Embedded methods (e.g., LASSO)	Select a subset of informative features	Reduces computational cost, improves model interpretability	May miss relevant features, may not be optimal for complex relationships
	Manifold Learning	Locally Linear Embedding (LLE), Isometric Mapping (Isomap)	Identify and exploit underlying low-dimensional manifold structure	Preserves local neighborhood relationships, handles non-linear data	Computationally expensive, may not be robust to noise

Table 6 employs SVMs to classify Earnings Management based on characteristics such as aggressive, conservative, genuine, and off-balance sheet activities. The evaluation metrics—Accuracy, Precision, Recall, and F1 Score—assess SVMs' performance in categorizing earnings management practices within each category. In Aggressive Earnings Management, characterized by irregular accruals and excessive revenue recognition, SVM exhibits robust performance with 83.2% Accuracy, 82.1% Precision, 84.7% Recall, and 83.9% F1 Score. These metrics demonstrate a strong ability to classify aggressive earnings management with a balanced approach to false positives and negatives. Similarly, SVM performs well in Conservative Earnings Management, associated with income understatement and reserve manipulation, attaining 79.5% Accuracy, 78.3% Precision, 81.2% Recall, and 79.8% F1 Score. These measurements underscore the model's precision and recall in detecting prudent earnings management.

SVM excelled in categorizing Real Activities Earnings Management involving manipulation of operating expenses and related party transactions. With 77.8% Accuracy, 76.7% Precision, 79.1% Recall, and 77.9% F1 Score, the model effectively identified real activities-related earnings management strategies, demonstrating a balanced precision and recall. Similarly, in Off-Balance Sheet Activities Earnings Management, covering non-consolidated and special purpose organizations, the SVM performed well with 74.2% Accuracy, 72.9% Precision, 76.7% Recall, and 74.8% F1 Score. These metrics highlight the model's ability to detect off-balance sheet earnings management, including managing false positives and negatives. In summary, Table 6 outlines SVMs' performance in identifying earnings management categories based on essential criteria, revealing their capability to capture subtle patterns within each category and providing valuable insights for financial data practitioners and researchers.

Table 6: Earnings Management Classification with Support Vector Machines (SVMs).

Category	Key Features	Accuracy	Precision	Recall	F1 Score
Aggressive	Unusual accounting accruals, excessive revenue recognition	0.832	0.821	0.847	0.839
Conservative	Understatement of income, manipulation of reserves	0.795	0.783	0.812	0.798
Real Activities	Manipulation of operating expenses, transactions with related parties	0.778	0.767	0.791	0.779
Off-Balance Sheet Activities	Non-consolidated entities, special purpose entities	0.742	0.729	0.767	0.748

Table 7 conducts a comparative assessment between ANNs and SVMs in the classification of Earnings Management, evaluating their performance and computational efficiency. ANNs achieved an accuracy range of 85.7% to 89.3%, surpassing SVMs with an accuracy range of 75.2% to 84.5%. Notably, ANNs demonstrated superior total classification accuracy. Precision for positive events ranged from 84.2% to 88.7% for ANNs, outperforming SVMs with a precision range of 73.1% to 82.9%. Consequently, ANNs exhibited more accurate positive predictions. In terms of recall, ANNs ranged from 85.9% to 90.1%, showcasing their ability to capture positive instances, whereas SVMs exhibited a recall range of 76.9% to 84.3%. This signifies that ANNs excelled in identifying real positives. The F1 Score, balancing precision and recall, ranged from 85.1% to 88.9% for ANNs, while SVMs exhibited a precision-recall balance ranging from 75.0% to 83.6%, indicating a superior performance by ANNs. In computational efficiency, SVMs outperformed ANNs, demonstrating clearer rules and feature importance with better resource efficiency. Although ANNs excel in capturing complex non-linear correlations, they demand more computational power. Conversely, SVMs, while slightly less accurate, offer interpretability and resource efficiency, establishing a trade-off between ANN-SVM earnings management categorization.

Table 7: Comparative Analysis of ANNs and SVMs for Earnings Management Classification.

Metric	ANNs	SVMs
Accuracy	0.857 - 0.893	0.752 - 0.845
Precision	0.842 - 0.887	0.731 - 0.829
Recall	0.859 - 0.901	0.769 - 0.843
F1 Score	0.851 - 0.889	0.750 - 0.836
Computational Efficiency	Lower Efficiency	Higher Efficiency
Insights	More complex non-linear relationships	Clearer rules and feature importance

Table 8 unveils intricate non-linear patterns in earnings management components from ANNs. Board Independence exhibits independence with a coefficient of 0.321 and a large standard error of 0.119, emphasizing its non-linear nature. The interaction term "Board Independence * CEO Duality" introduces a non-linear reinforcement (0.482 coefficient). CEO Duality, with standard errors of -0.278 and 0.154, further emphasizes the non-linear relationship with Board Independence, as indicated by the marginal effect of 0.084. Ownership Concentration, independent with a -0.087 coefficient and 0.072 standard error, displays a non-linear U-shaped influence on profitability management, evident in the quadratic term "Ownership Concentration^2" with a coefficient of 0.059. Growth Opportunities, independent with a 0.154 coefficient and 0.051 standard error, interacts non-linearly with Accounting Conservatism, highlighting their intricate connection and refining earnings management by 0.048. Accounting conservatism exhibits independence in the model, characterized by a -0.241 coefficient and 0.087 standard error. The non-linear relationship "Growth Opportunities * Accounting Conservatism" introduces intricate dynamics, with a marginal effect of -0.071 when Growth Opportunities and Accounting Conservatism are interconnected. Additional non-linear trends arise from quadratic factors, notably "Ownership Concentration^2" and "Growth Opportunities * Accounting Conservatism." The quadratic term "Ownership Concentration^2" with a coefficient of 0.059 signifies a U-shaped connection. The marginal effect of "Growth Opportunities * Accounting Conservatism" is -0.072, further highlighting its complex nature. The control variable Transparency, with a coefficient of 0.134 and a standard error of 0.052, exerts an influence on earnings management. Diagnostic tests affirm the model's efficacy in explaining a substantial variance in profits management, as indicated by an F-statistic of 5.23 and a high R-squared value of 0.783. Additionally, industry influences contribute to enhancing the model's explanatory power.

Table 8: Non-Linear Patterns Uncovered by ANNs.

Variable	Type	Coefficient	Std. Error	Marginal Effect	Interaction Term
Board Independence	Independent	0.321***	0.119	-0.123	Board Independence * CEO Duality
CEO Duality	Moderator	-0.278**	0.154	0.084	Board Independence * CEO Duality
Ownership Concentration	Independent	-0.087	0.072	0.035	Ownership Concentration^2
Growth Opportunities	Independent	0.154***	0.051	0.048	Growth Opportunities * Accounting Conservatism
Accounting Conservatism	Independent	-0.241***	0.087	-0.071	Growth Opportunities * Accounting Conservatism
Board Independence * CEO Duality	Interaction	0.482***	0.13	0.146	-
Ownership Concentration^2	U-shaped	0.059**	0.027	-0.018	-
Growth Opportunities * Accounting Conservatism	Interaction	-0.072**	0.031	-0.021	-
Transparency	Control	0.134	0.052	0.042	-
F-statistic:				5.23 ***	
R-squared:				0.783	
Diagnostic Tests				***	
Industry Effect				Yes	

Discussion and Findings

This study aimed to explore the influence of corporate governance structures on earnings management strategies in Saudi Arabian corporations, employing advanced machine learning techniques such as SVMs & ANNs in conjunction with a regression model. The research employed a multimodal methodology, incorporating moderating and control variables. Moderating factors, including firm size and profitability, were considered to assess their impact on the relationship between corporate governance practices and earnings management. Control variables, such as industry dummies, year dummies, leverage, growth, and auditor reputation, were introduced to account for external influences on earnings management (Attia et al., 2022).

Table 1 provides descriptive statistics for key study variables, including the mean and standard deviation of the EM measure, board size, board independence, CEO duality, ownership structure, firm size, profitability, leverage, growth, and auditor reputation. Understanding the distribution of these variables in Saudi Arabian companies is crucial for comprehending corporate governance and financial processes, as reflected in the range from minimum to maximum values. In Table 2, pairwise correlations reveal significant links between variables. Notably, the negative correlation between EM and board independence suggests that companies with more independent directors may engage in less aggressive earnings management. Conversely, the positive association between EM and CEO duality implies a connection to enhanced earnings management. These findings contribute to our understanding of how firm governance arrangements impact earnings management (Rahman et al., 2021).

Table 6 depicts non-linear patterns in ANNs, showcasing coefficients, standard errors, marginal effects, and interaction variables. Noteworthy findings include the complex interplay between board independence, CEO duality, and profitability management. The U-shaped ownership concentration relationship and nuanced effects of growth potential and accounting conservatism underscore the intricacies of corporate governance. In Table 7, SVM model parameters and performance metrics demonstrate profitability classification effectiveness. The choice of kernel functions (linear, RBF, Polynomial) influences accuracy, precision, recall, and F1 score. The RBF kernel's heightened accuracy positions it as a suitable choice for detecting non-linear correlations. These insights aid practitioners and researchers in selecting models based on interpretability and computing efficiency (Al Lawati et al., 2021).

Table 8 presents non-linear patterns, quadratic correlations, and interaction effects discovered by ANNs. Positive coefficients for board independence, negative coefficients for CEO duality, and positive coefficients for interaction terms affirm the model's validity, emphasizing intricate interconnections. The U-shaped ownership concentration and nuanced interactions of growth potential and accounting conservatism contribute to understanding corporate governance intricacies. This study unveils the intricate relationship between Saudi Arabian corporations' governance procedures and earnings management, surpassing linear models with advanced machine learning. The findings challenge traditional assumptions, revealing the complexity of governance influences on Saudi Arabian financial reporting standards (Al-Najjar & Assous, 2021; Alroqy & Aljaaid, 2016; Dokas, 2023).

Analysing high-dimensional data from board meeting minutes and annual reports unveils diverse earnings management practices in Saudi Arabia. The study underscores the importance of qualitative data in governance investigations. Additionally, the findings highlight the moderating roles of firm size and profitability in the link between corporate governance and earnings management, emphasizing the necessity of tailored governance advice for Saudi Arabian firms. This study contributes both theoretically and practically to understanding governance-earnings management dynamics and improving governance practices in Saudi Arabia's distinctive business environment (Kinyeki, 2022; Rahman et al., 2021).

In summary, the integration of machine learning and regression analysis enhances the investigation of corporate governance and earnings management in Saudi Arabian firms. Utilizing descriptive statistics, pairwise correlations, ANN non-linear patterns, and SVM classification provides insights into the intricate relationships between corporate governance structures and financial practices. These discoveries offer valuable guidance for stakeholders, policymakers, and researchers seeking to enhance corporate governance and mitigate earnings management risks within the Saudi Arabian context.

5. Conclusion

This study provides comprehensive insights into the intricate profit management strategies and corporate governance structures of Saudi Arabian firms. Notably, the analysis reveals a nuanced connection between earnings management and board independence, indicating that a greater proportion of independent directors correlates with reduced earnings manipulation. This aligns with the conventional belief that independent boards serve as effective checks and balances, promoting transparency and accountability in financial reporting. Conversely, the positive correlation between CEO duality and earnings management underscores the challenges associated with combining CEO and board chair roles, emphasizing the need to carefully consider board structures to mitigate managerial opportunism.

The study underscores ownership concentration's non-linear impact on earnings management, revealing a U-shaped correlation. Extreme ownership concentrations, whether low or high, may contribute to increased profit manipulation, while moderate concentrations could reduce such practices. This highlights the importance of a balanced ownership structure for effective corporate governance. The identification of interaction effects through machine learning underscores the necessity of a comprehensive approach to governance. Complex relationships between variables, such as accounting conservatism and growth prospects, offer insights into how diverse factors influence earnings management strategies. The findings have substantial implications for Saudi scholars, practitioners, and policymakers. Strengthening board independence and scrutinizing CEO duality can enhance financial transparency and integrity. Recognizing the non-linear connection between ownership concentration and earnings management underscores the importance of balancing ownership structures for improved governance. These insights contribute to the discourse on corporate governance in Saudi Arabia and provide a foundation for future research on financial reporting and governance frameworks.

Despite providing insights into earnings management and corporate governance in Saudi Arabian companies, this study has limitations. The use of historical financial data introduces potential hindsight bias. Quantitative corporate governance metrics may not capture qualitative governance aspects adequately. The limited generalizability of results may stem from the study's industry and geographic focus. Lack of qualitative data from surveys and interviews with corporate leaders may hinder a comprehensive understanding of governance decisions and profitability management techniques.

To overcome these limitations, future research endeavours could longitudinally examine the evolution of corporate governance frameworks and earnings management strategies. Utilizing qualitative methodologies such as case studies and interviews may elucidate the decision-making processes of corporate executives. A deeper comprehension of the impact of cultural and institutional factors on corporate governance practices in the Saudi Arabian context may enhance governance strategies. Employing natural language processing technologies to scrutinize corporate report content can provide insights into governance narratives. Lastly, investigating the influence of legislative changes on firm governance and earnings management would contribute to enhancing business practices in Saudi Arabia.

Research Implications

This article delves into the intricate dynamics of earnings management and corporate governance in Saudi Arabian firms, employing advanced regression models and machine learning techniques. Key findings highlight the impact of earnings management on board independence, underscoring the role of independent boards in fostering financial transparency. Simultaneously, the study reveals a nuanced relationship between CEO duality and earnings management, emphasizing the importance of balancing leadership roles. Artificial neural networks uncover non-linear trends, shedding new light on how ownership concentration influences earnings management. These insights hold implications for investors, boards, policymakers, and auditors, guiding governance enhancements, informing investment decisions, and refining auditing practices in Saudi Arabia's evolving business landscape. The study's contributions extend beyond linear models, leveraging advanced machine learning to unravel complex linkages shaping financial reporting. By exploring non-linear patterns and high-dimensional data, the research advances corporate governance analysis, incorporating industry-specific parameters and moderating variables for broader relevance. This study propels academic understanding and provides actionable guidance for policymakers, corporate boards, and practitioners, fortifying governance structures and mitigating earnings management risks in the distinctive Saudi Arabian business context.

This study significantly enhances theoretical insights into the intricate interplay between corporate governance structures and earnings management strategies, particularly within Saudi Arabian enterprises. Leveraging advanced machine learning, the research uncovers non-linear patterns and relationships, contributing to the depth of corporate governance theory. The inclusion of high-dimensional data, including qualitative textual information, enriches theoretical frameworks, emphasizing the significance of qualitative insights in governance processes. The study further explores the influence of cultural and institutional factors specific to Saudi Arabia on the complex relationship between governance variables and earnings management in emerging economies. Through the analysis of moderating variables and earnings management types, it enriches theoretical debates, highlighting the interdependent nature of governance practices and offering a more nuanced understanding of earnings management tactics.

Acknowledgement

This work was supported through the Ambitious Funding track by the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia [Grant 6123].

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